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SCIENTIFIC PAPERS.

A REVISION OF THE AMERICAN LEMNACEAE OCCURRING NORTH OF MEXICO.

BY CHARLES HENRY THOMPSON.

Hitherto no revision of the Lemnaceae for the North American continent has been published, though a number of botanists have made some special study of the order at various periods. In 1839, Schleiden* published a monograph of the then known species in which occurs reference to a few of the American forms. In 1867, Austin † published in Gray's Manual the species of the northeastern United States. The year following Hegelmaier's ‡ general monograph appeared, in which are recorded the descriptions of many species from America previously unknown. Contemporaneously with these latter gentlemen Dr. Engelmann of St. Louis, and Dr. Torrey of New York, made careful studies of the species occurring in their respective localities, as well as the abundant material sent them from other points, the results of which were published from time to time in the Bulletin of the Torrey Botanical Club. In 1878 Hegelmaier ¶ revised the order for Brazil, giving further knowledge of some species that occur also in North America. In 1895, he ‖ again published a review

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* Schleiden, M. J. Prodromus monographiae Lemnacearum oder Conspectus generum atque specierum. Linnaea. **13**: 385–392. 1839.

† Austin, C. F. Lemnaceae.—Gray, A., Man. Bot. 478. 1867. [5th ed.]

‡ Hegelmaier, Friedr. Monogr. Lemnaceen. May 1868.

¶ Hegelmaier, Friedr. Lemnaceae.—Martius, Fl. Bras. 3^2: 1–24. Feb. 1878.

‖ Hegelmaier, Friedr. Systematische Uebersicht der Lemnaceen. Engler's bot. Jahrb. 21^3: 268–305. Jan. 1895.

Separates issued Nov. 1, 1897.

of his original monograph, installing therein many changes from his former classification and adding several new species and farther territorial distribution. Other isolated notes and descriptions of species of the order found in America have been published by various authors at different times.

It is the object of the present work to bring together the results of all these labors, together with my own researches of the past two years, into a revision that will give an accurate record of the Lemnaceae of North America, north of Mexico. This revision is based on a study of rich collections contained in the herbaria of the Missouri Botanical Garden, containing the Engelmann collection; of Columbia College, containing the Torrey and Austin collections; of Harvard; and of the California Academy of Science: and furthermore upon a study of abundant living material of nearly every species, contributed by many correspondents or collected by myself. I desire to acknowledge as one of my greatest helps, in preparing this work, the exhaustive notes and sketches made by Dr. George Engelmann in his extensive study of the order during his lifetime. I am especially indebted to Miss Bertha Henney of Santa Cruz, California, for living material collected at that place and in San Francisco, and for valuable field-notes which have greatly aided to clear up many doubtful points that have hitherto existed concerning the western forms. Lastly my sincere thanks are due to Dr. Wm. Trelease at whose suggestion the work was undertaken and to whom, for his kind aid in many ways, is largely due any merit it may possess.

In classification I have followed, in a general way, that of Hegelmaier's revision of his monograph, he being the recognized authority on the order, deviating from it only where a thorough study of a group or species seemed, to my mind, to demand a change. For instance, I have reversed the positions of *Wolffia* and *Wolffiella*, being convinced that from a morphological standpoint *Wolffiella* is more closely related to *Lemna* than is *Wolffia*.

In synonymy I have aimed to cite all original descriptions of the American species, and in addition to include those published names which are found occurring in the collections examined. In these herbaria occur many manuscript names which are of interest only in designating various forms. These it seems wise to omit.

Lemnaceae is an order comprising four well defined genera and about twenty-eight species, distributed throughout the torrid and temperate zones. In our range the four genera are represented by about thirteen species and one variety. Of these perhaps but two species and the variety are peculiar to it alone and ten are found only in the western hemisphere. To some extent the classification must necessarily be incomplete and perhaps slightly erroneous, due largely to the fact that in almost every species there is a strong tendency to vary widely according to the environments, and further because the flowers and fruit are but partially known in some species and wholly unknown in others. Again a difficulty is met with in undertaking a classification when it is found that a single species may have at least three marked stages of growth differing from each other so widely as to give rise to different specific names for each. In several species I recognize two stages which I designate as the active stage, the period when vegetative reproduction goes on most vigorously, and the fruiting stage, or that period when the fruit is being produced, at which time the fronds are always smaller and more or less unsymmetrical. In other species three marked stages are recognized, the two above mentioned and a third which may be considered a resting stage. This, from its importance, deserves more than passing mention. Hegelmaier,* in his monograph, describes and figures what he terms "winter fronds" in *Spirodela polyrrhiza*. The name, no doubt, is derived from the fact that in this stage the plants were found to sink to the bottom of ponds and there pass the winter, and the following spring to rise to the surface again and begin anew the cycle of life. Biscoe[*] also made a careful study of this stage with like conclusions. This my study of the species proves true, but not the whole truth. I find that in midsummer if a pond gradually disappears through evaporation these "winter fronds" are produced in abundance, and as the shore line recedes they are found for a considerable distance up the bank, still in an apparently healthy state. To my knowledge ponds have entirely dried away and remained so during the winter, yet when the spring rains again renewed them the *Spirodela* reappeared, the first fronds emerging from these "winter buds." Hence they are a protection as well against drought as lower temperature. Hegelmaier[†] also described a form of *Lemna gibba* in which the fronds are flat and three-nerved, much resembling *L. minor*. Guppy,[‡] from a long series of observations and study, found that these "flat fronds" performed the same functions as the "winter fronds" of *S. polyrrhiza*, sinking to the bottom of ponds in the fall and rising to the surface again in the spring, then continuing active vegetative reproduction. In the middle of June, 1897, I discovered a pond in St. Louis abundantly covered with sterile *L. minor*. The first part of September I again visited it hoping to secure fruiting specimens. The water had almost entirely disappeared by evaporation and only a small number of normal plants remained. These were sterile, but I discovered that they were producing a modified frond similar to the "winter frond" of *S. polyrrhiza*. Further search revealed these modified fronds in abundance in the remaining water, in the oozy mud along its margin, and still farther away from the water where the mud was quite hard. In all instances they preserved a healthy appearance, and when placed later in a vessel of fresh water began active growth by sending out normal fronds. A diligent search through the dead plants left by the receding water failed to reveal a single fruit.

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* Hegelmaier, Friedr. Monogr. Lemnac. 81. May 1868.

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[*] Biscoe, T. D. The winter state of our Duckweeds. Am. Nat. 7: 257–268. *pl. 3*. May 1873.

[†] Hegelmaier, Friedr. Monogr. Lemnac. 146. May 1868.

[‡] Guppy, H. B. Habits of *Lemna minor*, *L. gibba* and *L. polyrrhiza*. Journ. Linn. Soc., Bot. 30: 325. 6 Oct. 1894.

Thus we have three species which produce specialized fronds whose ultimate object is to reproduce the species, independent of the normal sexual method, after a more or less prolonged resting period, in much the same manner as the tubers of *Nelumbium* and many other aquatics. Hence the terms "resting fronds" and "resting stage" are here used in preference to "winter fronds."

These various forms and stages have wrought much confusion. We find that a stage of one species so closely resembles one of another species as to cause the very common error of a wrong determination of specimens in herbaria. It is this confused condition, as well as the lack of an American standard to follow, that has induced me to undertake a revision that it is hoped will meet the requirement of a clear understanding of the order.

ANALYTICAL KEY.

I. Fronds with roots and two reproductive pouches.
  A. Roots more than one, fascicled. SPIRODELA.
    Fronds rounded obovate, 5-15-nerved. *S. polyrrhiza.*
  B. Root solitary. LEMNA.
    a. Fronds long stipitate, mostly submerged, forming large masses. *L. trisulca.*
    b. Fronds short stipitate or sessile, floating on the surface.
      1. Symmetrical or nearly so.
        * Oblong-obovate; fruit more or less lenticular.
          + Upper surface uniformly green; margin of the fruit unappendaged. *L. minor.*
          + + Upper surface mottled with irregular brown streaks; margin of the fruit with rounded wing lobes. *L. gibba.*
        ** Oblong to elliptical, small, green on both surfaces; fruit elongated, erect. *L. minima.*

2. Unsymmetrical.
* Obliquely obovate, papulose along the median line.
+- Convex to strongly gibbous beneath, obscurely 3–7-nerved; rootsheath unappendaged. *L. gibba.*
+- +- Flat beneath, moderately thick, distinctly 3–nerved; rootsheath with lateral wing appendages. *L. perpusilla.*
* * Long oblong, thin.
+- Strongly 3-nerved; rootsheath with lateral wing appendages. *L. perpusilla trinervis.*
+- +- Obscurely 1-nerved; rootsheath unappendaged. *L. cyclostasa.*

II. Fronds rootless, with but one reproductive pouch.
A. Fronds thin, ligulate. WOLFFIELLA.
a. Saber form; stipe insertion at the lower right-hand angle of the two walls of the pouch.
1. Fronds 14–21 times as long as broad, apex flagellate; stipe scar raised. *W. Floridana.*
2. Fronds 3–5.5 times as long as broad, apex bluntly rounded; stipe scar sessile, rounded. *W. oblonga.*
b. Tongue shaped, 1.5-3.5 times as long as broad, large; stipe insertion on the margin of the lower wall of the pouch. *W. lingulata.*
B. Fronds thick, more or less globular. WOLFFIA.
a. More or less flattened above, gibbous beneath, brown punctate.
1. Rounded ovate, strongly gibbous, sparingly punctate beneath, dorsal surface with a prominent papule near the center. *W. papulifera.*
2. More or less oblong, less gibbous, abundantly punctate on both surfaces, dorsal surface smooth. *W. punctata.*
b. Globose to ellipsoidal, not punctate, dorsal surface with usually about three inconspicuous papules along the median line. *W. Columbiana.*

LEMNACEAE.

Each plant is a fleshy or membranaceous modified stem (frond) floating free, beneath or upon the surface of pools or slowly running streams. The inflorescence is a very simple form of spadix consisting of one pistillate and one or two staminate flowers inserted upon a common point. The pistillate flower consists of a single carpel containing from one to several ovules, and the staminate flower of a single stamen.

Spirodela Schleiden, Linnaea. **13**: 391. 1839.

Stipe attached (peltately) to the frond back of and under the basal margin. Reproductive pouches two, triangular, opening as clefts in either margin of the basal portion of the frond. Roots more than one, fascicled. Spadix of one pistillate and two staminate flowers from the vegetative reproduction pouches; spathe sac-like; filaments curving upward from the margin of the frond; anthers bilocellate, dehiscing longitudinally. Fruit rounded lenticular, with wing margins.

SPIRODELA POLYRRHIZA (L.) Schleiden, Linnaea. **13**: 392. 1839. *Lemna polyrhiza* Linn. Sp. Plant. 970. 1753. *Lemna thermalis* Beauv. Mémoire sur les Lemna. 13. 11 Sept. 1815. *Lemna umbonata* A. Br. ex Hglm. Monogr. Lemnac. 156. May 1868.

Fronds solitary or united in colonies of 2–5, roundish obovate, slightly unsymmetrical, flat on both sides, sessile or short stipitate, stipe deciduous; apex obtuse or acute; 5–15-nerved, 2.5–4.5 mm. wide by 2.5–8 mm. long (usually 3–6 mm. long). Roots 4–16; rootcap large, straight, .176–.235 mm. in diameter by 1.3–1.5 mm. long, sharp pointed. Usually sterile and wintering over by specialized resting fronds. Fertile fronds extremely rare. Spathe a complete sac, opening at the upper end. Anthers .33 mm. in transverse diameter; pollen grains spinulose, globose to ellipsoidal, .018–.023 mm. in diameter. Pistil flask shaped; ovules 2, anatropous, or frequently 1 and then amphitropous. Fruit somewhat winged along the margin; seed slightly compressed, smooth; spongy testa very thick; operculum distinct; endosperm dark brown, thin; albumen considerable; embryo cylindrical, nearly as long as the seed.— Abundant in ponds, rarely occurring in running water, thriving for a considerable time on very wet mud. A cosmopolitan species occurring abundantly throughout our range.— Plate 1 A.

But one other species * is known in the western hemisphere and that is peculiar to South America.

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* SPIRODELA PUNCTATA (Meyer) Thompson. *Lemna? punctata* Meyer, Prim. Fl. Esseq. 262. 1818. Fronds solitary or more commonly 2–4, rarely more, successive generations cohering in a regular chain; elliptical to slightly obovate-oblong, unsymmetrical, inclined to kidney form; 1–1.6 mm. wide by 2–3.1 mm. long — averaging about 1.34 mm. by 2.56 mm.; thick; obscurely 3-nerved; convex above, frequently with a slight protuberance just over the point of the root attachment, flat beneath; apex rounded or rarely obtuse; base rounded, prominently winged with a narrow membranaceous margin extending almost half the length of the frond. Stipe persistent or deciduous, jointed at the peltate attachment to the frond. Abundantly punctate over both surfaces with brown epidermal pigment cells. Upper surface with numerous stomata. Roots one, two or three, fascicled, long, fragile, brown colored when dry; rootcap long and narrow (.18 mm. in diameter by 2.5 mm. long), straight, sharp pointed. Spathe ovoid to globose, sac form with opening at the top through which project the reproductive organs. Spadix of two staminate and one pistillate flower. Stamens with long filaments; anthers dehiscing longitudinally (?); pollen grains papillose, .021–.023 mm. in diameter. Pistil long ovate, slightly compressed; ovule solitary, amphitropous. Fruit lenticular, short and broad, 1 mm. high by 1.2 mm. broad; the upper lateral margins projecting into rounded wing-like lobes; style short. (Strikingly like a one-seeded fruit of *Lemna gibba*).— Plate 1 B.

The plants which furnish the original description by Meyer (Meyer, G. F. W. Prim. Fl. Esseq. [Introd. page vii.] 1818) were collected about 1814 in the territory of the Hollandish colonies along the Essequibo river in what is now British Guiana, South America. Since that time, so far as I can learn, no other collection of the species has been published. Neither Schleiden (Prodromus Monographiae Lemnacearum. Linnaea. **13**: 392. 1839) nor Hegelmaier (Monograph Lemnaceen. 150. 1868) was able to learn more of the plant than the original description gave.

My description of the species is based on a collection of the plants, in the United States national herbarium, made by the United States South Pacific Exploring Expedition under the command of Capt. Wilkes, U. S. N. in 1838–42. The specimens were collected at Orange Harbor, on the Tierra del Fuego island, at the extreme south end of South America, some time between Feb. 18 and April 17, 1839, this being the period of the expedition's stop at Orange Harbor, according to the report of Jenkins.

Inasmuch as these two localities are so widely separated and since it has been impossible to secure either specimens or further publications of Meyer's original plants, some question may arise as to the identity of the two collections. Yet in view of the fact that many species of the order have even a far wider range, and since the Fuegian plants answer Meyer's

Specimens examined from Ontario (Fowler, 1883); Maine (Fernald, 1891); Vermont (Brown); Rhode Island (Thurber, 1846); Connecticut (Eaton; Eames, 1895); New York (Austin; Leggett, 1870, fertile); New Jersey (Parker, 1861); Pennsylvania (Thurber, 1848); Virginia (Vasey, 1874); South Carolina (Ravenel, 1872); Florida (Curtiss, no. 4544, 1894; Nash, no. 2282, 1895); Michigan (Bigelow, 1865; Gillman, 1871); Wisconsin (Hale, 1861); Illinois (Hall, 1867; Schneck, 1893, resting fronds); Tennessee (Gattinger, 1882); Minnesota (Hale, 1861); Iowa (Fink, no. 398, 1894); Missouri (Broadhead, 1864; Engelmann, 1867; Trelease, 1895; Widmann, 1895; Bush, no. 1583, 1892 and no. 797, 1896; Thompson, 1896); Arkansas (Engelmann, 1835); Louisiana (Dr. Hale, about 1830–40; Hilgard, 1867); Nebraska (Webber, 1889; Rydberg, no. 1258, 1893); Kansas (Kellerman and Carleton, 1884; Norton, 1893; K. S. A. C., no. 533, 1895); Texas (Mex. Bound. Surv., no. 1412, 1855–56; Reverchon, no. 492, 1877); Utah (Jones, no. 5979, 1894); Nevada (Watson, no. 1126, 1867); Oregon (Hall, no. 498, 1871); California (Brewer, no. 2190, 1860–62; S. B. and W. F. Parish, no. 1100, in part, 1881; Rattan, no. 59, 1884).

Lemna Linn. Sp. Plant. 970. 1753.

Stipe attached to the basal margin of the frond. Reproductive pouches two, triangular, opening as clefts in either margin of the basal portion of the frond. Root solitary. Spadix of one pistillate and two staminate flowers, produced in the vegetative reproduction pouches; spathe various; filaments curving upward from the margin of the frond. Anthers bilocellate, dehiscing transversely.

* Spathe sac-like; ovules amphitropous when solitary, anatropous when more than one; rootsheath long, cylindrical, unappendaged.

+ Fronds sessile or very short stipitate, more or less wing-margined on either side of the base, subpeltately attached; fruit rounded lenticular; rootcap bluntly rounded.

++ Fronds pale and usually strongly gibbous beneath, green and brown mottled above; fruit winged with rounded lobes at the upper margin on either side of the stigma; seeds one or more.

LEMNA GIBBA Linn. Sp. Plant. 970. 1753. *Telmatophace gibba* Schleid. Linnaea **13**: 391. 1839.

Fronds solitary to four in a group, commonly two, orbicular to obovate, 2–4 mm. wide by 2–5 mm. long, thick,

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description so admirably in all essential characters, I feel perfectly justified in identifying the one with the other.

convex and slightly keeled above and flat or slightly convex to hemisperically gibbous beneath, cavernous throughout, cavities very large in the gibbous portion; slightly to decidedly unsymmetrical, usually 3–5 nerved; base usually acute and commonly with narrow wing margins. Rootcap cylindrical, straight or slightly curved, about .25 mm. in diameter by 1.3–2.2 mm. long. Spathe irregularly torn by the developing flowers; pollen grains globose, spinulose; pistil clavate, compressed; stigma concave; style long or in the fruit short; ovules 1–7. Fruit symmetrical, purple tinted; seeds with thick covering, prominently and unevenly ribbed, with many transverse striations.— Abundant in ponds. A cosmopolitan species occurring only in the western and southwestern part of our range.—Plate 2 A.

This species is reported from the eastern States, but collections from east of the Mississippi river have failed to come under my observation. These are probably the ones Austin* refers to his varieties of *L. minor*.

Specimens examined from Nebraska (Rydberg, no. 1503, 1893); Texas (Wright; Mex. Bound. Surv., no. 1411, 1855-56); Wyoming (Forwood, 1882); New Mexico (Wright, no. 1892, 1852); Arizona (Coues and Palmer, no. 445, 1865; Toumey, 1894–95); California (Bigelow, 1853–54; Brewer, no. 30, 1860–62; Torrey, no. 504, 1865; Kellogg and Harford, no. 948, 1868–69; Bolander, 1870; Palmer, no. 372, 1875; Cooper, 1879; Henney, nos. 104, 106, 109, 112, 1896; Thompson, no. 207, 1896).

++ ++ Fronds green or purplish beneath, slightly convex, uniformly bright green above; fruit not winged; seed always solitary.

LEMNA MINOR Linn. Sp. Plant. 970. 1753.

Fronds solitary or few clustered, round to elliptic-obovate, 1.5–3 mm. wide by 2–4 mm. long; symmetrical, or in fruit slightly unsymmetrical; thickish; convex on both sides, upper surface sometimes slightly keeled and with a row of papules along the midnerve, the apical one usually quite prominent; obscurely 3-nerved; cavernous throughout. Rootcap comparatively short. Spathe with a small cleft opening which is irregularly torn by the developing floral organs. Pistil clavate; ovule solitary. Fruit symmetrical, projecting about one-third beyond the margin of the frond; style short. Seed oblong-ovate; operculum prominent, directed forward, rounded; ribs 12–15, uneven, high; seed coat thick, with many transverse striations.— Prolific, soon covering the surface of stagnant ponds. One of the most widely distributed species, occurring throughout our range.— Plate 2 B.

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* Austin, C. F. Lemnaceae, in A. Gray, Man. Bot. 479. 1867 [5th ed.]

The species is quite variable and in the vegetative stage very closely approaches the nongibbous resting stage of *L. gibba*. Striking examples of this are the Fink collections in Iowa (nos. 275, 399, 1894).

Specimens examined from Nova Scotia (Fowler, 1868); Ontario (Gillman, 1870); Vancouver Island (Macoun, 1887); Massachusetts (Trelease, 1881); Connecticut (Eames, 1894); New York (Wright; Clinton, 1867); New Jersey (Austin, 1862; Leggett, 1868); Pennsylvania (Austin); Florida (Chapman, 1868; Canby, no. 17, 1869; Curtiss, no. 2695, 1881); Michigan (Bigelow, 1867; Gillman, 1870); Wisconsin (Blount; Trelease 1887); Indiana (Simmons, 1895); Illinois (Hall, 1861; Eggert, 1887; Thompson, no. 253, 1897); Minnesota (Sheldon, 1892); Iowa (Fink, nos. 275, 399, 1894); Missouri (Engelmann, 1865; Bush, no. 523, 1896; Henney and Thompson, 1896); Louisiana (Robbins, 1860; Hilgard, 1867); South Dakota (Rydberg, no. 1066, 1892); Nebraska (Webber, 1889; Clements, no. 2800, 1893; Rydberg, no. 1257, 1893); Indian Territory (Palmer, no. 316a, 1868); Colorado (Brandegee, 1876; Jones, no. 603, 1878); New Mexico (Fendler, no. 1008, 1847; Bigelow, 1853); Idaho (Sandberg, no. 801, 1892); Utah (Jones, no. 1693, 1880, and no. 5321, 1894); Nevada (Bailey, no. 1125, 1867; Watson, 1867); Washington (Henderson, no. 2534, 1892); Oregon (Hall, nos. 496, 497, 1871); California (S. B. and W.F. Parish, no 914, 1881; Thompson, 1896).

+ + Fronds with a long stipe attached directly to the basal margin; young fronds projecting at right angles to the parent, forming a cross; fruit broadly oblong lenticular; rootcap acute pointed.

LEMNA TRISULCA Linn. Sp. Plant. 970. 1753.

Fronds aerial and submerged, long persistent, usually many generations remaining attached and forming dense masses; oblong to oblong-lanceolate; slightly unsymmetrical and frequently a little falcate; 2–3 mm. wide by 5–10 mm. long; without papules of any kind; converging terminal margins serrate and commonly fluted; apex acute; base hastate in the young fronds, in the older ones attenuated into a flat stipe about .5 mm. wide by 4–13 mm. long; proliferous from both pouches. Aerial fronds cavernous throughout the central portion, shorter stipitate and less persistent. Submerged fronds longer, more persistent, thinner and with long twisted stipes. Roots frequently absent; rootsheath soon disappearing. Seed prominently 12–15 ribbed with numerous transverse striations.—Prolific. This is a cosmopolitan species of very wide distribution, adapting itself to much colder temperature than any other species; not infrequently a hardy perennial. Common in springs and running water throughout our range.— Plate 2 C.

Specimens examined from Saskatchewan (Bourgeau, 1857–58); Ontario (Fowler, 1881); Vancouver Island (Macoun, 1887); Massachusetts (Boott, 1859 and 1867); New York (Clinton; Austin; Britton, 1892); New Jersey (Austin, 1866); Michigan (Bigelow, 1865; Gillman, 1871); Wisconsin (Hale; Lapham); Illinois (Engelmann, 1838; Hall, 1861); Minnesota (Ballard, 1893); Iowa (Hitchcock; Evermann, 1893); Missouri (Bush, no. 1495, 1886 and no. 536, 1896; Steadman, 1896); Arkansas, (Blankinship, 1888); Nebraska (Hayden, 1853; Webber, 1889; Williams, no. 7, 1890; Rydberg, no. 1397, 1893); Texas (Wright, no. 674; Schott, 1855–56; Mexican Boundary Survey, no. 1410, 1855–56); Wyoming (Rose, no. 401, 1893; Nelson, no. 2284, 1896; Adams on U. S. Geol. Survey, 1871; Knowlton, 1887,— the last two from Yellowstone National Park); Colorado (Brandegee, 1881); New Mexico (Wright, no. 1890, 1851–52; Fendler, no. 1007, 1874); Utah (Watson, no. 1123, 1869; Ward, no. 594, 1875; Jones, no. 6019, 1894); Nevada (Stretch, 1865; Watson, no. 1123, 1868); Arizona (Palmer, no. 531, 1890); Oregon (Howell, 1879); California (Redfield, no. 8062, 1872; Austin, 1878; Lemmon, 1879).

* * Spathe open; ovule solitary, obliquely orthotropous with the micropyle inclined toward the apex of the frond; stipe attached to the basal margin.

+ Frond 3-nerved; rootsheath with lateral longitudinal wing appendages; rootcap long, cylindrical, straight, sharp-pointed.

++ Fronds obliquely obovate to oblong-obovate, thick, nerves obscure.

LEMNA PERPUSILLA Torr. Fl. N. Y. 2: 245. 1843. *Lemna paucicostata* Hglm. ex Engelm. in A. Gray, Man. Bot. 681. Jan. 1868. [5th ed. 8th iss.].—Hglm. Monogr. Lemnac. 139. May 1868.

Fronds solitary or more commonly long coherent, forming groups of 2-6 mature plants; sessile or very short stipitate; strongly unsymmetrical, or rarely nearly symmetrical in robust sterile individuals; 1.2–2.5 mm. wide by 2–3.5 mm. long; cavernous throughout. Apical dorsal papule usually prominent and frequently a row of smaller ones along the midnerve. Wings of the rootsheath varying from narrow to broad. Rootcap .85–2 mm. long. Fruit unsymmetrical, usually attached obliquely forward and outward, ovoid to oblong, ending in a rather prominent eccentric style; seed slightly compressed, ovoid to obliquely oblong, oblique in the utricle; seed coat thick, ribs prominent, varying from 12–16 in number, with numerous transverse striations.— Common in stagnant ponds throughout the eastern portion of our range and extending southward into South America. Rather variable.— Plate 3 A.

Dr. Torrey's original description indicates an anatropous ovule, but I have examined type material from his herbarium and find the ovule orthotropous, as described in Gray's manual.*

The original material of *Lemna paucicostata* Hglm. was collected about St. Louis and sent to Hegelmaier by Dr. Engelmann. These gentlemen studied the species together and in their correspondence referred to it as a variety of the Torrey species. In 1868 Engelmann published it as a distinct species, giving Hegelmaier the credit. This was four months previous to the appearance of Hegelmaier's monograph of the order, and with it his own description. I have collected quantities of material in the vicinity of St. Louis and identified it with the abundant type specimens of *paucicostata* in the Engelmann herbarium, and in neither of these do I find any constant difference from Torrey's species. In fact the descriptions of the two differ but slightly except in the number of ribs on the seed. This my study finds quite variable in the same pond though other characters are identical. Therefore I unhesitatingly place the American form heretofore credited to *paucicostata* under Torrey's *perpusilla.*

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* Gray, A. Man. Bot. 552. 1889. [6th ed.]

Specimens examined from Massachusetts (Clark); New York (Torrey, 1829); New Jersey (Austin, 1869); Pennsylvania (Austin, 1860; Small, 1891); Virginia (Coville, no. 35, 1890); South Carolina (comm. Torrey); Florida (Garber, 1869; Nash. no. 1591, 1894); Illinois (Engelmann, 1872; Schneck, no. 6, 1886; Eggert, 1896; Thompson, 1896; Hall); Missouri (Broadhead, 1864; Engelmann, 1867; Eggert, 1875; Bush. no. 584, 1896; Tracy, no. 19; Henney, 1896; Thompson, 1896); Arkansas (Eggert, 1896); Nebraska (Rydberg, no. 1723, 1893); Kansas (Norton. no. 532, 1895).

++ ++ Fronds more or less oblong, thin, strongly 3-nerved.

LEMNA PERPUSILLA Torr. var. TRINERVIS Austin, in Gray, Man. Bot. 479. 1867. [5th ed.]

Fronds solitary or cohering in twos or threes, rarely more; oblong to obovate-oblong; very slightly convex above, flat beneath; more elongated and less unsymmetrical than the species; apex more or less abruptly obtuse angled. Inflorescence and flowers as in the species. Fruit ovate, usually pointed by a rather long terminal style, nearly or quite symmetrical; seed ovate, erect or rarely slightly oblique. Otherwise partaking of the specific characters.— A characteristic variety of about the same territory as the type, growing with it or alone.— Plate 3 B.

Commonly mistaken for *L. cyclostasa* but readily distinguished, even the sterile fronds, by the three prominent nerves.

Specimens examined from New Jersey (Leggett, 1869); Illinois (Thompson, 1896); Tennessee (Gattinger, no. 2693, 1880); Missouri (Bush; Blankinship, 1889; Henney, 1896; Thompson, 1896); Louisiana (Dr. Hale, about 1830–40); Kansas (Hitchcock, no. 848, 1896); Indian Territory (Bush, no. 1334, 1895).

+ + Fronds obscurely 1-nerved or nerveless; rootsheath unappendaged.

++ Fronds thin, without papules; rootcap strongly curved, tapering to a small rounded apex.

LEMNA CYCLOSTASA (Ell.) Chev. Fl. Par. **2**: 256. 1827. Schleid. Linnaea. **13**: 390. 1839. *Lemna minor* var.? *Cyclostasa* Elliott, Bot. S. Carol. and Ga. **2** : 518. 1824. *L. Valdiviana* Ph. Linnaea. **33**: 239. 1864. *L. Torreyi* Aust. in Gray, Man. Bot. 479. 1867. [5th ed.]. *L. abbreviata* Hglm. Engler's bot. Jahrb. **21^3**: 298. Jan. 1895.

Fronds solitary or grouped, more commonly 2–8 cohering in a more or less curved chain; oblong to obovate-oblong; usually somewhat falcate, particularly in the smaller fruiting plants; .7–1.5 mm. wide by 2.3–4.5 mm. long; base usually strongly unsymmetrical, tapering into a short stipe or frequently sessile; cavernous in the middle portion only. Roots long; rootsheath large, thin, cylindrical; rootcap variable in length, usually long. Fruit slightly unsymmetrical, elongated ovate, pointed by the long straight or sometimes curved style; usually half the length of the frond; seed oblong-ovoid, with thick coat particularly at the apex, 12–29 ribbed, abundantly transversely striated.— An American species growing abundantly in our range from the Atlantic to the Pacific oceans, absent only in the northern part, extending southward into South America.— Plate 3 C.

The variableness of this species in the form of its fronds has given rise to many varietal and even specific names, but though frequently one individual may be remarkably different from another, yet I find no constant difference in any one particular that I would feel justified in recognizing a variety by, and furthermore I find all gradations of forms between the extremes. One such variation reported as a variety and later as a doubtful species is Hegelmaier's *Lemna* (*Valdiviana* var.) *abbreviata*, which I recognize only as a more symmetrical form of the species.

Specimens examined from Massachusetts (Kennedy, 1894; Deane, 1894); Rhode Island (Osterhout, 1893–94); Connecticut (Evans, 1889; Eames, 1895 — both exceptionally large plants); New York (Torrey; Leggett, 1870; Young, 1873); New Jersey (Austin, 1862); South Carolina (Ravenel, 1850); Georgia (Ravenel, 1881; Schweinitz); Florida (Garber; Canby, no. 16, 1869; Ravenel, 1877; Nash, no. 894, 1894); Ohio (Hacker, 1895); Illinois (Engelmann, 1838); Missouri (Bush, 1895;

Trelease, 1895; Widmann, 1895); Arkansas (Engelmann, 1835; Eggert, 1892); Texas (Lindheimer, 1847–48); Wyoming (Rose, no. 401, in part, 1893); New Mexico (Wright, no. 1891, 1851); Utah (Jones, 1880 and no. 5983g, 1894); Nevada (Watson, no. 1124, 1868; Coville, 401, 1891); Arizona (Palmer, 1865; Coues and Palmer, no. 451, 1865); California (Bigelow, 1853–54; Bolander, no. 2662, 1866; Orcutt, 1883 — a very large form; Henney, nos. 107, 113b, 1896).

++ ++ Fronds thicker, with a row of papules along the midnerve; rootcap slightly curved, cylindrical, with bluntly rounded apex.

LEMNA MINIMA Philippi, Linnaea. **33**: 239. 1864. *Lemna platyclados* Hglm. Engler's bot. Jahrb. **21**^{3}: 298. Jan. 1895.

Fronds solitary or cohering in groups of 2–4, commonly 2; symmetrical or with stipe scar but little to one side of the median line; oblong to elliptical; .9–2.7 mm. wide by 1.5–3.9 mm. long; apex rounded; lower surface flat or slightly convex, upper surface slightly to prominently convex, with thin margin entirely around the frond; cavernous in the middle portion only; commonly nerveless. Rootsheath thin, cylindrical. Rootcap usually short, rarely perfectly straight. Pistil short clavate, with concave stigma. Seed oblong, pointed, about 16-ribbed, with many transverse striations.— An American species occurring in the south and west parts of our range, from there south into South America.— Plate 3 D.

This species seems to have at least two fairly well-defined stages in its growth. The first may be termed the normal or more constant, for in it the fronds are uniformly very small (averaging 1.1 mm. wide, by 1.7 mm. long) and strikingly convex on the upper surface and of a straw yellowish or sometimes pale green color. The second is more variable in its habits and is characterized chiefly by larger sized, thinner green colored fronds, and more vigorous growth throughout. This answers perfectly Hegelmaier's description of *Lemna* (*Valdiviana* var.?) *platyclados*. The fronds readily change from one form to the other.

Specimens examined from Georgia (Ravenel, 1881); Florida (Curtiss, no. 4543, 1894); Kansas (Cragin, 1884); Wyoming (Forwood, 1882);

California (Bolander, 1867; Kellogg and Harford, nos. 946 and 947, 1868-69; Jones, no. 2356, 1881; S. B. and W. F. Parish, no. 1100 in part, 1881; Cleveland, 1884; Hansen, no. 482, 1893; Thompson, nos. 202, 205, 208, 1895-96; Henney, nos. 103, 105, 116, 1896).

Wolffiella Hegelmaier, Engler's bot. Jahrb. **21**^{3}: 303. Jan. 1895.

Stipe attached on the margin of the single reproductive pouch. Pouch triangular, opening as a cleft in the basal margin of the frond. Fronds rootless, thin, unsymmetrical, curved in the form of the segment of a band, abundantly punctate on both surfaces with brown epidermal pigment cells. Flowers and fruit unknown.

* Saber form; stipe insertion at the lower angle of the two walls of the pouch.

WOLFFIELLA FLORIDANA (J. D. Smith).

Wolffia gladiata var. *Floridana* J. D. Smith, Bull. Torr. Bot. Club. **7**: 64. June 1880.— Thompson, Ligulate Wolffias of the United States. Rept. Mo. Bot. Gard. **7**: 101-111. *pl. 64-66.* 26 May 1896. *W. Floridana* J. D. Smith ex Hegelmaier, Engler's bot. Jahrb. **21**^{3}: 305. Jan. 1895.

Fronds solitary or more commonly long coherent for several generations, in time forming densely interwoven masses; elongated strap-shaped, doubly curved to falcate and band form; tapering from the broad, rounded, oblique base to a long attenuated apex, frequently a little contracted just above the base; .4-.7 mm. in widest part, by 5.5-8.5 mm. long, about 14-21 times as long as broad; thin; cavernous throughout except a small portion of the apex; only a small area above the base exposed to the air. Basal portion of the attenuated stipe persistent, situated at the lower right hand angle of the reproductive pouch, connecting the two walls. Pouch elongated triangular or the upper angle rounded.— Occurring only in the southeastern part of our range.— Plate 4 A.

Closely related to *W. gladiata* Hglm., of Mexico, but differing in its constantly more narrow form, long flagellate apex, proportionately broader base, in being more cavernous, and having fewer and larger punctations.

Specimens examined from Georgia (Waite); Florida (Ravenel, 1877; Smith and Austin, 1878; J. D. Smith, 1878–80; Curtiss, no. 2699, 1881; Swingle, no. 71, 1892; Nash, no. 254, 1894); Missouri (Eggert; Bush, 1895; Widmann, 1895; Trelease, 1897); Arkansas (Eggert, 1892); Louisiana (Dr. Hale, about 1830–40); Texas (Joor, about 1877).

WOLFFIELLA OBLONGA (Ph.) Hglm. Engler's bot. Jahrb. **21**^{3}: 303. Jan. 1895. *Lemna oblonga* Philippi, Linnaea. **29**: 45. 1857. *Wolffia oblonga* (Ph.) Hglm. Monogr. Lemnac. 131. 1868. *W. lingulata* Hglm. var. *minor* Hglm. Lemnac. in Martius Fl. Bras. **3**^{2}: 10. Feb. 1878.

Fronds at maturity solitary or in pairs, rarely three cohering; long oblong or commonly gradually tapering from the obliquely rounded base to the slightly narrower bluntly rounded apex; slightly falcate, rarely nearly straight; basal portion alone exposed to the air; .53–1 mm. broad by 1.7–4.6 mm. long, about 3–5.5 times as long as broad. Reproductive pouch isosceles-triangular with the base a little narrower than the sides. Stipe scar small, blunt, rounded, situated at the lower right-hand juncture of the two walls of the pouch, conspicuous from the cluster of pigment cells it contains.— A Mexican and South American species, at present reported from but one locality in our range.— Plate 4 B.

Hegelmaier* was in doubt as to the advisability of separating this species from *W. lingulata* on the ground of the striking similarity of his *W. lingulata* var. *minor* to *W. oblonga*. My examination of a number of collections, both from Mexico and South America, prove beyond a doubt in my mind that his variety is not one of *W. lingulata* but merely an elongated form of *W. oblonga*. In the variety from Mexico city collected by Louis Hahn in 1868 and determined by Hegelmaier I find the stipe scar constantly as in *W. oblonga*, while in diminutive forms of *W. lingulata* I find the position of the stipe scar constantly the same as in the larger more normal form.

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* Hegelmaier, Friedr. Systematische Uebersicht der Lemnaceen. Engler's bot. Jahrb. **21**^{3}: 303–304. Jan. 1895.

Specimens examined from California (S. B. and W. F. Parish, no. 1100, in part, 1881, San Bernardino Valley).

* * Tongue-shaped; stipe insertion on the margin of the lower wall of the pouch.

WOLFFIELLA LINGULATA Hglm. Engler's bot. Jahrb. **21**^{3}: 303. Jan. 1895. *Wolffia lingulata* Hglm. Monogr. Lemnac. 132. May 1868.—Thompson, Ligulate Wolffias of the United States. Rept. Mo. Bot. Gard. **7**: 101–111. *pl. 64–66.* 26 May 1896.

Fronds at maturity solitary or rarely in twos; ovate to oblong tongue-shaped; slightly unsymmetrical; 1.7–3 mm. broad by 2.7–6.6 mm. long, about 1.5–3.5 times as long as broad; membranaceous; cavernous throughout the lower central portion; only a small part of the frond, above the base, exposed to the air; lateral margins upturned along the middle portion, immature fronds frequently flat. Reproductive pouch usually equilaterally triangular, sometimes an isosceles triangle with the base a little narrower or broader than the sides. Stipe scar evident, on the margin of the lower wall of the pouch, to the right of the median line, slightly raised, truncate.—A Mexican species which at present time is reported from but one locality in our range. These specimens were collected by my brother and myself in the irrigation canals of Kern County, California, in 1895–96, nos. 201, 204, 209.— Plate 4 C.

Wolffia Horkel ex Schleiden, Linnaea. **13**: 389. 1839.

Stipe attached under the solitary reproductive pouch and but a few cells from the margin. Fronds small, thick, fleshy, more or less globular, and rootless. Reproductive pouch funnel form with its circular opening at the basal end of the frond. Spadix of one pistillate and one staminate flower, bursting through the tissues of the upper surface of the frond, without spathe; pistillate flower one carpeled and one ovuled; staminate flower of one stamen; anther unilocellate, dehiscing by a slit across the top, the two halves opening as reflex valves.

* More or less flattened above, gibbous beneath, brown punctate.

WOLFFIA PAPULIFERA n. sp.

Fronds slightly unsymmetrical, apparently symmetrical to the unaided eye; obliquely broadly ovate in horizontal outline; 1 mm. broad by 1–1.5 mm. long; apex rounded; upper surface flat at the margin, gradually ascending to form a single prominent large conical papule on the median line immediately below the center; under surface strongly gibbous, having the form of the half of a longitudinally divided egg; stomata numerous over the entire upper surface; abundantly punctate with brown epidermal pigment cells above, less so beneath. Cells of the upper portion small, of the lower large. Floating at the surface with the entire upper surface exposed to the air. Flowers and fruit unknown.—Thus far found only in Missouri, densely covering stagnant pools.— Plate 4 D.

This species is allied to the Brazilian type, but differs in its larger size, proportionately greater width, rounded apex, the presence of the large papule, and in the smaller number of pigment cells.

Collected by B. F. Bush, in Varner river, near Kennett, Mo., July, 1895, and again in quantity by myself (no. 250), at Columbia, Mo., June 5, 1897.

WOLFFIA PUNCTATA Grisebach, Fl. Brit. W. Ind. Isl. 512. 1864.

Fronds symmetrical; elliptical to ovate oblong; .35–.53 mm. broad by .58–.82 mm. long; upper surface flat or very slightly convex, gradually rising at the acute apex like the bow of a boat; under surface gibbous; floating at the surface of pools with the entire upper surface of the frond exposed to the air; stomata numerous; profusely punctate throughout with brown epidermal pigment cells. Upper portion of the fronds consisting of small celled tissue, and the lower of large cells. "Utricle ellipsoidal" (Grisebach). Flowers and fruit unknown with us.—Occurring, in our range, east of the Mississippi river, from the Lake region to the Gulf of Mexico.—Plate 4 E.

This species as well as our North American plants have heretofore been referred to *W. Brasiliensis* Wedd. In comparing our form with Weddell's original material, as well as his description * of the species, I find a marked difference in the more elongated and less gibbous fronds, the upturned acutish apex and more numerous pigment cells.

Specimens examined from Ontario (Payne); Michigan (Bigelow, 1867); Illinois (Hall, 1867; Eggert, 1891); Tennessee (Gattinger).

* * Globose to ellipsoidal, not punctate.

WOLFFIA COLUMBIANA Karst. Bot. Unters. **1**: 103. 1865.

Fronds ellipsoidal to globose; symmetrical; upper surface convex with usually about three small inconspicuous papules in a row along the median line; .54–.8 mm. wide and deep by .48–1 mm. long; floating at the surface of the water with only a very small portion of the upper surface exposed to the air. In this area are to be found but a few (1–10) stomata. Pigment cells none. The body tissue is uniformly large celled throughout.—Occurring abundantly in ponds throughout the eastern half of Canada and the United States.—Plate 4 F.

Specimens examined from Ontario (Payne; Gillman, 1869); Massachusetts (Robbins, 1870); New York (Craig; Austin, 1866); New Jersey (Austin, 1867); Pennsylvania (Parker, 1868; Crawford, 1894; Kront, 1894); South Carolina (Ravenel, 1872); Florida (Curtiss); Michigan

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* Weddell, H. A. Observations sur une espèce nouvelle du genre *Wolffia*. Ann. Sci. Natur. III. **12**: 170. 1849.

(Bigelow, 1867; Gillman, 1870; Campbell, 1886); Illinois (Hall, 1867; Eggert, 1891; Thompson, 1896); Kentucky (Barclay, 1895); Tennessee (Gattinger, 1882); Iowa (Hitchcock, 1888); Missouri (Engelmann, 1867; Bush, 1896; Thompson, no. 15, 1896); Louisiana (Riddell, 1867).

EXPLANATION OF PLATES ILLUSTRATING LEMNACEAE.

The figures are for the most part camera sketches of living material prepared at various times by the author. A few details are reproduced from Dr. Engelmann's sketches.

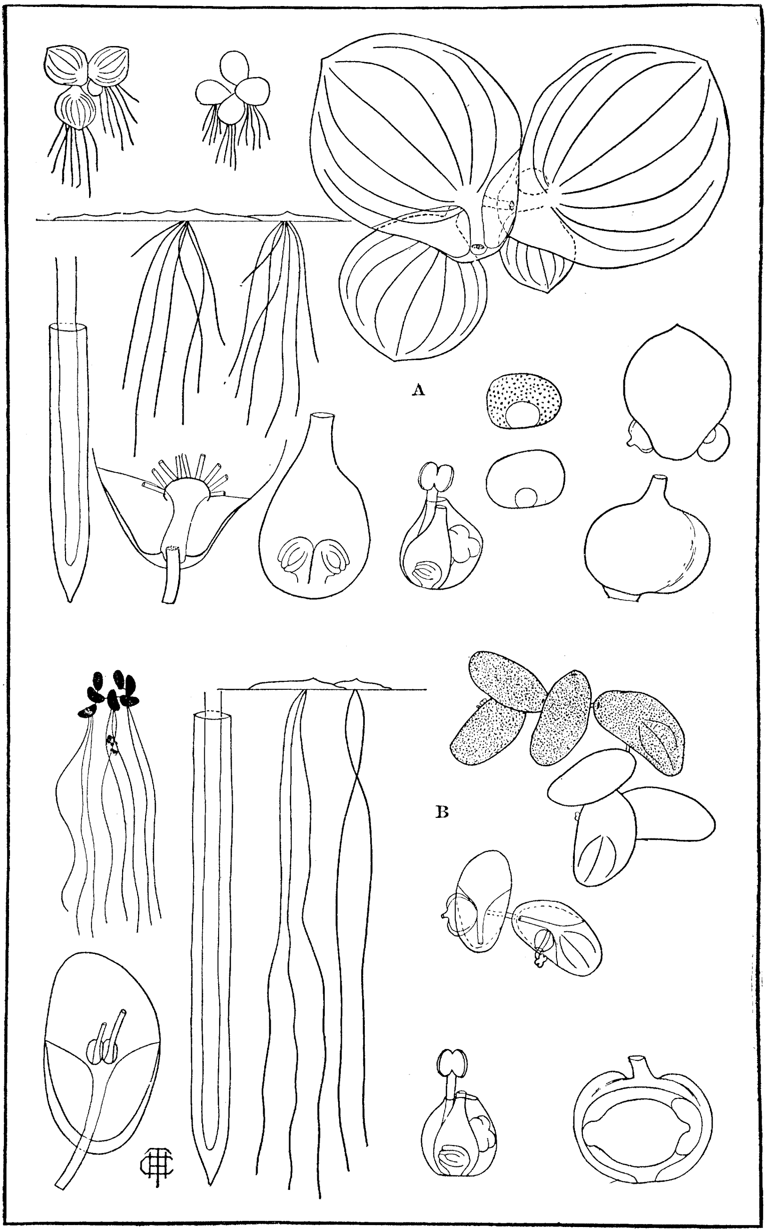
It has been the aim in each species to give only the distinguishing characters without going into the more minute structural details. In all species first is given a group of plants of natural size; a lateral view of the fronds on a water surface line, enlarged four diameters; a group of fronds enlarged five diameters, showing gross details; the basal portion of a frond enlarged five diameters, showing the attachment of the stipe, and in the first two genera showing the bases of the roots with their appendages. Also in each of these genera is shown a rootcap enlarged twenty-five diameters; an inflorescence enlarged fifteen diameters, showing spathe, pistil and two stamens. In a few instances a pistil is again represented enlarged thirty diameters. The fruit when represented is enlarged fifteen diameters and the seed ten diameters. In *Lemna minima* the seed is again enlarged to thirty diameters. In the genus *Wolffia* the fronds are again represented in lateral and basal views enlarged fifteen diameters.

Plate 1, A. *Spirodela polyrrhiza*, with details; B. *Spirodela punctata*, with details.

Plate 2, A. *Lemna gibba*, with details; B. *Lemna minor*, with details; C. *Lemna trisulca*, with details.

Plate 3, A. *Lemna perpusilla*, with details; B. *Lemna perpusilla* var. *trinervis*, with details; C. *Lemna cyclostasa*, with details; D. *Lemna minima*, with details.

Plate 4, A. *Wolffiella Floridana*, with details; B. *Wolffiella oblonga*, with details; C. *Wolffiella lingulata*, with details; D. *Wolffia papulifera*, with details; E. *Wolffia punctata*, with details; F. *Wolffia Columbiana*, with details; G. *Wolffia Brasiliensis*, with details.



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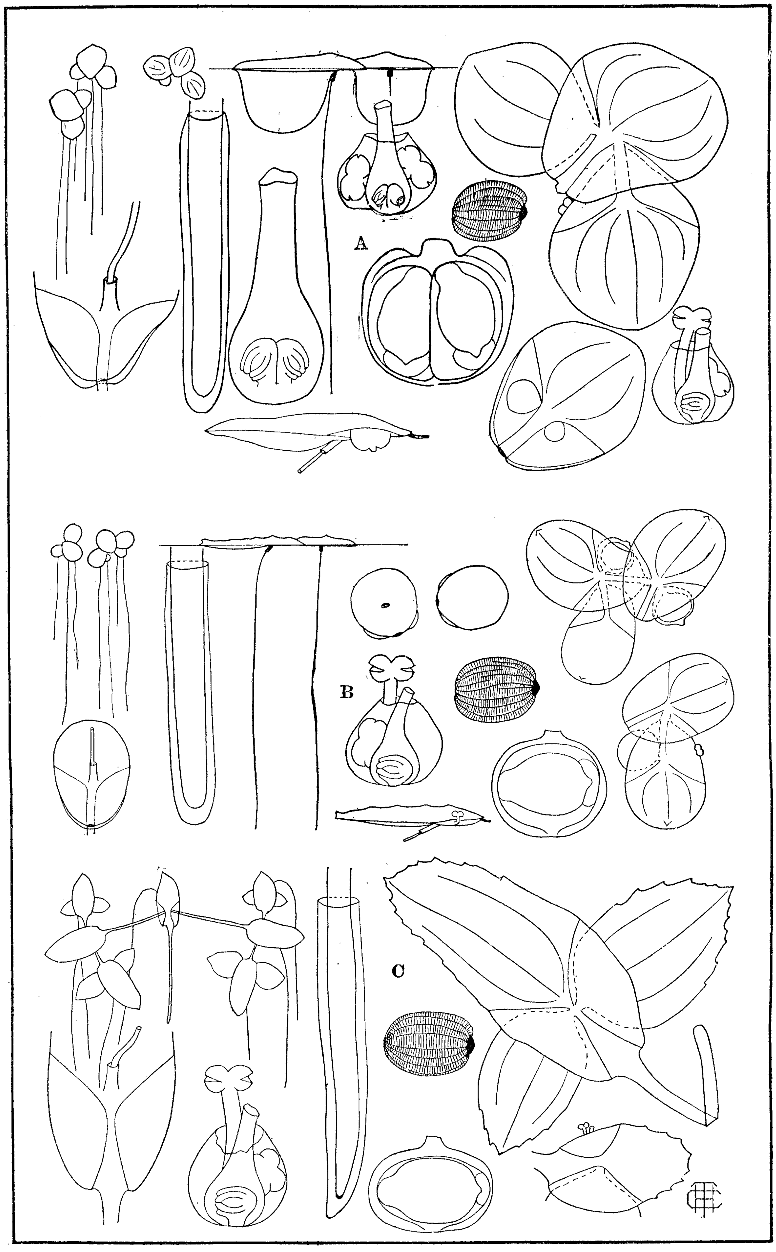

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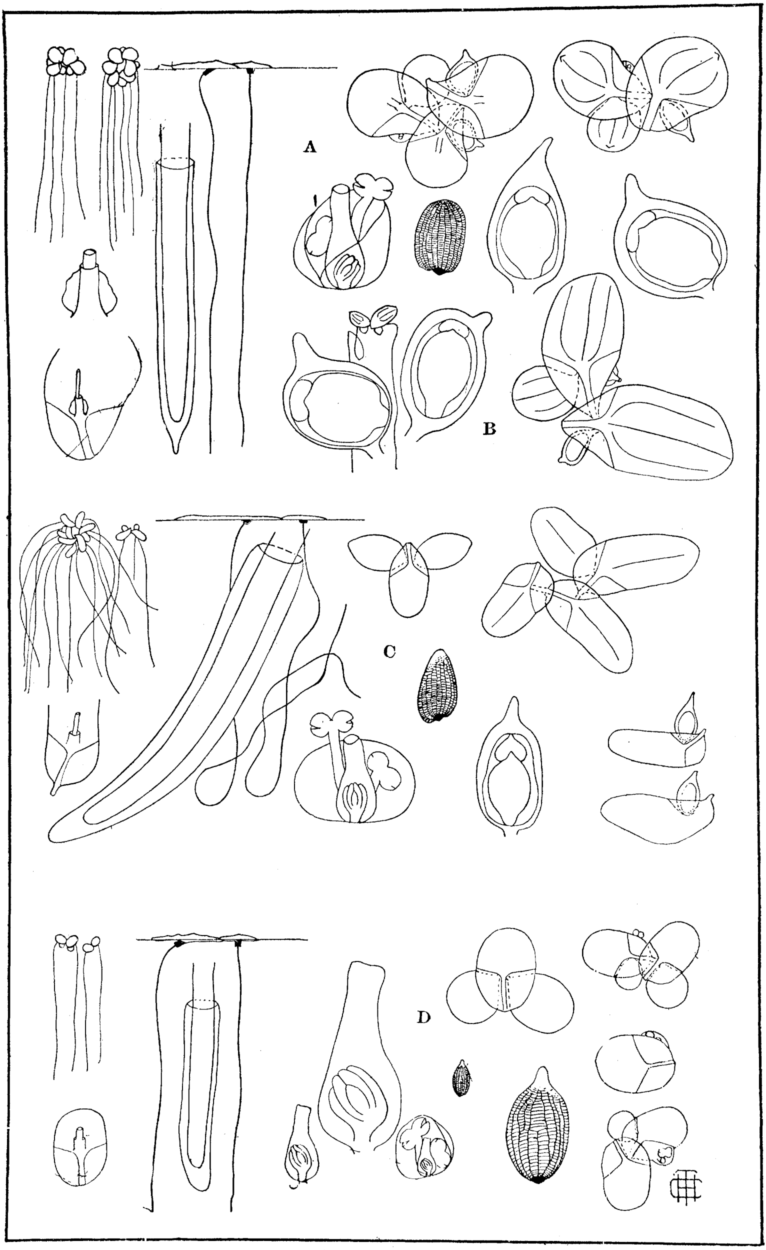

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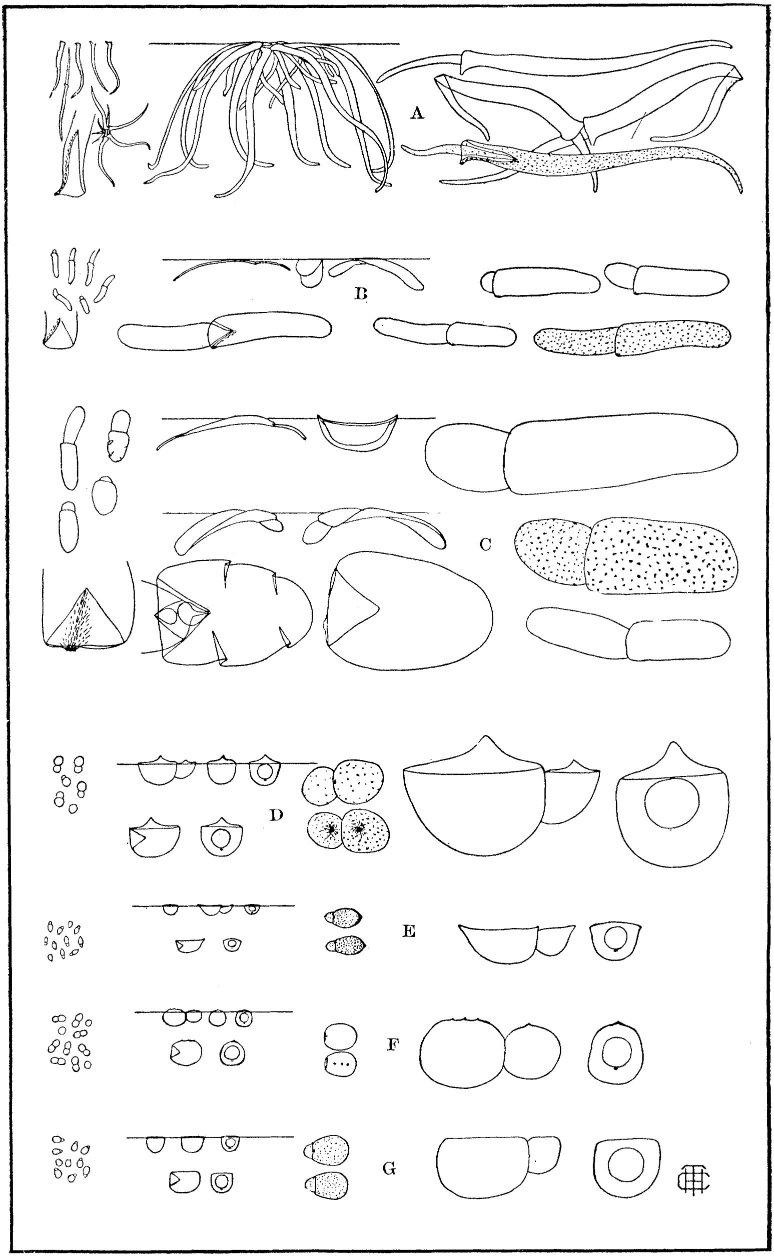

WOLFFIELLA AND WOLFFIA.